

CLAIMS

What is claimed is:

- 5 1. An operational amplifier comprising:
 - a first differential transistor pair which is disposed between a first power supply conductor and a second power supply conductor, and which receives differential input signals at a first differential input terminal and a second differential
 - 10 input terminal thereof;
 - a second differential transistor pair which is disposed between the first power supply conductor and the second power supply conductor, and which receives the differential input signals at a third differential input terminal and a fourth
 - 15 differential input terminal thereof;
 - a first current source circuit coupled between the first differential transistor pair and the second power supply conductor;
 - a second current source circuit coupled between the
 - 20 second differential transistor pair and the first power supply conductor;
 - an output terminal for outputting an output signal;
 - a first transistor for sourcing a drive output current via the output terminal;
 - 25 a second transistor for sinking a drive output current via the output terminal;
 - an output driver stage circuit for controlling the drive output current corresponding to a signal output potential level of the output signal;
 - 30 a first phase inverter circuit which responds to a drive

output potential level of the output driver stage circuit and which controls a circuit current of the first differential transistor pair in response to the rise or fall of the signal output potential level; and

5 a second phase inverter circuit which responds to the drive output potential level of the output driver stage circuit and which controls a circuit current of the second differential transistor pair in response to the rise or fall of the signal output potential level.

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2. An operational amplifier as set forth in claim 1, wherein the first current source circuit comprises:

15 a third transistor whose second electrode, i.e., control electrode, is coupled with the first phase inverter circuit, and whose first and third electrodes are coupled with the second power supply conductor and the first differential transistor pair, respectively; and

20 a third current source circuit which is coupled with the first differential transistor pair, the second power supply conductor, the output terminal of the operational amplifier, and the second electrode, i.e., control electrode, of the second transistor; and

wherein the second current source circuit comprises:

25 a fourth transistor whose second electrode, i.e., control electrode, is coupled with the second phase inverter circuit, and whose first and third electrodes are coupled with the first power supply conductor and the second differential transistor pair, respectively; and

30 a fourth current source circuit which is coupled with the second differential transistor pair, the first power supply

conductor, the output terminal of the operational amplifier, and the second electrode, i.e., control electrode, of the first transistor.

5 3. An operational amplifier as set forth in claim 2, further comprising first and second constant current source circuits which are coupled parallel to the first and second current source circuits, respectively.

10 4. An operational amplifier as set forth in claim 2, wherein the third current source circuit comprises fifth and sixth transistors,

the fifth transistor having the third electrode coupled with the first differential transistor pair, the second electrode, 15 i.e., control electrode, coupled with the output terminal of the operational amplifier, and the first electrode coupled with the third electrode of the sixth transistor, and

the sixth transistor having the third electrode coupled with the first electrode of the fifth transistor, the second 20 electrode, i.e., control electrode, coupled with the second electrode of the second transistor, and the first electrode coupled with the second power supply conductor, and

wherein the fourth current source circuit comprises seventh and eighth transistors,

25 the seventh transistor having the third electrode coupled with the second differential transistor pair, the second electrode, i.e., control electrode, coupled with the output terminal of the operational amplifier, and the first electrode coupled with the third electrode of the eighth transistor, and

30 the eighth transistor having the third electrode coupled

with the first electrode of the seventh transistor, the second electrode, i.e., control electrode, coupled with the second electrode of the first transistor, and the first electrode coupled with the first power supply conductor.

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5. An operational amplifier as set forth in claim 2, wherein the first phase inverter circuit comprises ninth, tenth and eleventh transistors,

10 the ninth transistor having the third electrode coupled with the first electrode of the tenth transistor, the second electrode coupled with the second electrode of the first transistor, and the first electrode coupled with the first power supply conductor,

15 the tenth transistor having the third electrode coupled with the second and third electrodes of the eleventh transistor and with the second electrode of the third transistor, the second electrode coupled with a first predetermined voltage, and the first electrode coupled with the third electrode of the ninth electrode, and

20 the eleventh transistor having the second and third electrodes coupled with the third electrode of the tenth transistor and with the second electrode of the third transistor, and the first electrode coupled with the second power supply conductor; and

25 wherein the second phase inverter circuit comprises twelfth, thirteenth and fourteenth transistors,

the twelfth transistor having the second and third electrodes coupled with the third electrode of the thirteenth transistor and with the second electrode of the fourth transistor,
30 and the first electrode coupled with the first power supply

conductor,

the thirteenth transistor having the third electrode coupled with the second and third electrodes of the twelfth transistor and with the second electrode of the fourth transistor,
5 the second electrode coupled with a second predetermined voltage, and the first electrode coupled with the third electrode of the fourteenth electrode, and

the fourteenth transistor having the third electrode coupled with the first electrode of the thirteenth transistor, the
10 second electrode coupled with the second electrode of the second transistor, and the first electrode coupled with the second power supply conductor.

6. An operational amplifier as set forth in claim 2, wherein the
15 output driver stage circuit comprises fifteenth, sixteenth, seventeenth, eighteenth and nineteenth transistors, and third, fourth and fifth constant current source circuits,

the fifteenth transistor having the third electrode coupled with the second electrodes of the sixteenth,
20 seventeenth and eighteenth transistors and with the third electrode of the sixteenth transistor, the second electrode coupled with the first current mirror circuit and with the load circuit, and the first electrode coupled with the second power supply conductor,

25 the sixteenth transistor having the second and third electrodes both coupled with the second electrodes of the seventeenth and eighteenth transistors and with the third electrode of the fifteenth transistor, and the first electrode coupled with the third constant current source circuit,

30 the seventeenth transistor having the third electrode

coupled with the second and third electrodes of the nineteenth transistor, with the second electrode of the second transistor, with the second electrode of the sixth transistor and with the second electrode of the fourteenth transistor, the second
5 electrode coupled with the second electrodes of the sixteenth and eighteenth transistors and with the third electrode of the sixteenth and fifteenth transistors, and the first electrode coupled with the first power supply conductor,

the eighteenth transistor having the third electrode
10 coupled with the fifth constant current source, with the second electrode of the first transistor, with the second electrode of the seventh transistor and with the second electrode of the ninth transistor, the second electrode coupled with the second electrodes of the sixteenth and seventeenth transistors, and
15 with the third electrodes of the fifteenth and sixteenth transistors, and the first electrode coupled with the first power supply conductor,

the nineteenth transistor having the second and third electrodes coupled with the second electrode of the first
20 transistor, with the second electrode of the sixth transistor, with second electrode of the fourteenth transistor, and with the third electrode of the seventeenth transistor, the first electrode coupled with the fourth constant current source circuit,

the third constant current source circuit being coupled
25 between the first power supply conductor and the first electrode of the fifteenth transistor,

the fourth constant current source circuit being coupled between the second power supply conductor and the first electrode of the nineteenth transistor, and

30 the fifth constant current source circuit being coupled

between the second power supply conductor and the third electrode of the eighteenth transistor.

7. An operational amplifier as set forth in claim 1, wherein the
5 transistors are field effect transistors each of which has the source electrode as the first electrode, the gate electrode as the second electrode and the drain electrode as the third electrode.
8. An operational amplifier as set forth in claim 1, wherein the
10 transistors are bipolar transistors each of which has the emitter electrode as the first electrode, the base electrode as the second electrode and the collector electrode as the third electrode.
9. An operational amplifier comprising:
15 a first input terminal and a second input terminal;
 a first differential transistor pair of a first conductivity type and a second differential transistor pair of a second conductivity type which is different from the first conductivity type, each of the second electrodes, i.e., control electrodes, of
20 transistors of the first and second differential transistor pairs being coupled with the first input terminal or the second input terminal;
 a first current mirror circuit which is coupled with one output of the first differential transistor pair, with one output
25 of the second differential transistor pair, and with a first power supply conductor;
 a second current mirror circuit which is coupled with the other output of the first differential transistor pair, with the other output of the second differential transistor pair, and with
30 the first power supply conductor;

a load circuit (MM9, MM10) which is coupled between the second differential transistor pair and a second power supply conductor;

5 an output driver stage circuit which is coupled with the coupling node between the first current mirror circuit and the load circuit, and which has two drive output terminals for controlling first and second output transistors;

10 the first transistor whose second electrode, i.e., control electrode, is coupled with one of the two drive output terminals of the output drive circuit, whose first and third electrodes are coupled with the first power supply conductor and an output terminal of the operational amplifier, respectively;

15 the second transistor whose second electrode, i.e., control electrode is coupled with the other of the two drive output terminals of the output drive circuit, whose first and third electrodes are coupled with the second power supply conductor and the output terminal of the operational amplifier, respectively;

20 first and second current source circuits which are coupled with the first and second differential transistor pairs, respectively, and which are controlled by the output drive signals of the output driver stage circuit;

25 a first phase inverter circuit which responds to a drive output potential level of the output driver stage circuit and which controls a circuit current of the first differential transistor pair in response to the rise or fall of the signal output potential level; and

30 a second phase inverter circuit which responds to the drive output potential level of the output driver stage circuit and which controls a circuit current of the second differential

transistor pair in response to the fall or rise of the signal output potential level.

10. An operational amplifier as set forth in claim 9, wherein
5 the first current source circuit comprises:

a third transistor whose second electrode, i.e., control electrode, is coupled with the first phase inverter circuit, and whose first and third electrodes are coupled with the second power supply conductor and the first differential transistor pair, respectively; and
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a third current source circuit which is coupled with the first differential transistor pair, the second power supply conductor, the output terminal of the operational amplifier, and the second electrode, i.e., control electrode, of the second transistor; and
15

wherein the second current source circuit comprises:

a fourth transistor whose second electrode, i.e., control electrode, is coupled with the second phase inverter circuit, and whose first and third electrodes are coupled with the first power supply conductor and the second differential transistor pair, respectively; and
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a fourth current source circuit which is coupled with the second differential transistor pair, the first power supply conductor, the output terminal of the operational amplifier, and the second electrode, i.e., control electrode, of the first transistor.
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11. An operational amplifier as set forth in claim 9, further comprising first and second constant current source circuits
30 which are coupled parallel to the first and second current

source circuits, respectively.

12. An operational amplifier as set forth in claim 10, wherein
the third current source circuit comprises fifth and sixth
5 transistors,

the fifth transistor having the third electrode coupled
with the first differential transistor pair, the second electrode,
i.e., control electrode, coupled with the output terminal of the
operational amplifier, and the first electrode coupled with the
10 third electrode of the sixth transistor, and

the sixth transistor having the third electrode coupled
with the first electrode of the fifth transistor, the second
electrode, i.e., control electrode, coupled with the second
electrode of the second transistor, and the first electrode
15 coupled with the second power supply conductor, and

wherein the fourth current source circuit comprises
seventh and eighth transistors,

the seventh transistor having the third electrode coupled
with the second differential transistor pair, the second
20 electrode, i.e., control electrode, coupled with the output
terminal of the operational amplifier, and the first electrode
coupled with the third electrode of the eighth transistor, and

the eighth transistor having the third electrode coupled
with the first electrode of the seventh transistor, the second
25 electrode, i.e., control electrode, coupled with the second
electrode of the first transistor, and the first electrode coupled
with the first power supply conductor.

13. An operational amplifier as set forth in claim 10, wherein
30 the first phase inverter circuit comprises ninth, tenth and

eleventh transistors,

the ninth transistor having the third electrode coupled with the first electrode of the tenth transistor, the second electrode coupled with the second electrode of the first
5 transistor, and the first electrode coupled with the first power supply conductor,

the tenth transistor having the third electrode coupled with the second and third electrodes of the eleventh transistor and with the second electrode of the third transistor, the second
10 electrode coupled with a first predetermined voltage, and the first electrode coupled with the third electrode of the ninth electrode, and

the eleventh transistor having the second and third electrodes coupled with the third electrode of the tenth
15 transistor and with the second electrode of the third transistor, and the first electrode coupled with the second power supply conductor; and

wherein the second phase inverter circuit comprises twelfth, thirteenth and fourteenth transistors,
20 the twelfth transistor having the second and third electrodes coupled with the third electrode of the thirteenth transistor and with the second electrode of the fourth transistor, and the first electrode coupled with the first power supply conductor,

the thirteenth transistor having the third electrode coupled with the second and third electrodes of the twelfth transistor and with the second electrode of the fourth transistor, the second electrode coupled with a second predetermined voltage, and the first electrode coupled with the third electrode
25 of the fourteenth electrode, and
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the fourteenth transistor having the third electrode coupled with the first electrode of the thirteenth transistor, the second electrode coupled with the second electrode of the second transistor, and the first electrode coupled with the second
5 power supply conductor.

14. An operational amplifier as set forth in claim 10, wherein the output driver stage circuit comprises fifteenth, sixteenth, seventeenth, eighteenth and nineteenth transistors, and third,
10 fourth and fifth constant current source circuits,

the fifteenth transistor having the third electrode coupled with the second electrodes of the sixteenth, seventeenth and eighteenth transistors and with the third electrode of the sixteenth transistor, the second electrode
15 coupled with the first current mirror circuit and with the load circuit, and the first electrode coupled with the second power supply conductor,

the sixteenth transistor having the second and third electrodes both coupled with the second electrodes of the seventeenth and eighteenth transistors and with the third
20 electrode of the fifteenth transistor, and the first electrode coupled with the third constant current source circuit,

the seventeenth transistor having the third electrode coupled with the second and third electrodes of the nineteenth transistor, with the second electrode of the second transistor, with the second electrode of the sixth transistor and with the second electrode of the fourteenth transistor, the second
25 electrode coupled with the second electrodes of the sixteenth and eighteenth transistors and with the third electrode of the sixteenth and fifteenth transistors, and the first electrode
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coupled with the first power supply conductor,

the eighteenth transistor having the third electrode coupled with the fifth constant current source, with the second electrode of the first transistor, with the second electrode of the seventh transistor and with the second electrode of the ninth transistor, the second electrode coupled with the second electrodes of the sixteenth and seventeenth transistors, and with the third electrodes of the fifteenth and sixteenth transistors, and the first electrode coupled with the first power supply conductor,

the nineteenth transistor having the second and third electrodes coupled with the second electrode of the first transistor, with the second electrode of the sixth transistor, with second electrode of the fourteenth transistor, and with the third electrode of the seventeenth transistor, the first electrode coupled with the fourth constant current source circuit,

the third constant current source circuit being coupled between the first power supply conductor and the first electrode of the fifteenth transistor,

the fourth constant current source circuit being coupled between the second power supply conductor and the first electrode of the nineteenth transistor, and

the fifth constant current source circuit being coupled between the second power supply conductor and the third electrode of the eighteenth transistor.

15. An operational amplifier as set forth in claim 9, wherein the transistors are field effect transistors each of which has the source electrode as the first electrode, the gate electrode as the second electrode and the drain electrode as the third electrode.

16. An operational amplifier as set forth in claim 9, wherein
the transistors are bipolar transistors each of which has the
emitter electrode as the first electrode, the base electrode as the
5 second electrode and the collector electrode as the third
electrode.